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A DOWNWARD ATMOSPHERIC CIRCULATION, AS ONE  
CAUSE OF EXTREMES OF COLD.

BY LORIN BLODGET.

*(Read before the American Philosophical Society, May 1st, 1874).*

The system of atmospheric circulation which gives us a general easterly movement in temperate latitudes, scarcely needs further explanation, yet the recent establishment of observatories on Mount Washington and on Pike's Peak, are found to afford positive evidence in verification of such movement that is full of interest. The easterly current on the top of Mount Washington, at least, is almost constant and with extreme velocity, in a direction the resultant of which is almost due east, and there are no conditions apparent to throw doubt on the general assumption that this is the returning current of a vast system of atmospheric circulation to and from the tropics, primarily, through which the heat and humidity of the tropics are widely diffused at both the northern and southern temperate belts.

But I propose only to refer to some deductions that have for some time past impressed me with great force, as to the origin of certain almost inexplicable facts of our climate, at points near the northern border of this system of circulation; and particularly in the colder parts of the United States, east of the Rocky Mountains, in winter, and indeed, in all the cold months. I had the honor to lay before this Society on a former occasion, some suggestions as to the origin of the extremes of cold observed at various points, chiefly of the northwestern interior, and to express the conviction that these extremes were not propagated, or transferred along the surface, as a part of what is usually thought to be the surface circulation from the west; and also that they do not move down—that is, along the surface—from the north, or from any other point of the compass. On the contrary, they appear to be *instituted or established* at the point of their most extreme existence, as if brought down from the upper atmosphere, or as if the result of the action of causes extraneous to the earth's atmosphere.

The recent extension of observations to the territories of the plains, and to posts on both sides of the Rocky Mountains, has given us a new basis of facts for the discussion of the symmetrical climates of the eastern United States, as I may call them, since their principal changes are usually quite symmetrical;—and it has disclosed the fact that no symmetry or correspondence of phenomena can be traced across the Rocky Mountains, connecting any great storm, or any area of excessive heat, or excessive cold, with any like condition at the east. I have been particularly observant of such facts as I could obtain in regard to this point along the northern belt, for the purpose, first, of tracing, if possible, the origin of the remarkable extremes of cold occurring in Dakota and Minnesota; and have spent much time in examining these cases, with the result of coming to the conclusion that there is absolutely no connection

or movement from Oregon or Washington Territories eastward to the country of the Upper Missouri, or to the line of Red River of the north. There is no progressive march of a refrigerated area, or of a barometric depression, along that line from west to east across the mountains. And the line of separation is far east of the mountains themselves, apparently as far as the Yellowstone, nearly, though of course, there is some partial correspondence of phenomena west of this line, and some general relation of the principal conditions. And here I anticipate the more precise results I hope to obtain, in explanation and corroboration of these positions, in order to put forth a view of the causes of these phenomena which appear to me new, and which I hope others will examine also. It is that in the system of atmospheric circulation before referred to, there must be a general descent of atmospheric volumes to the surface at or near the northern border of the belt ;—that this descent may be of masses sometimes large, and depleted of both heat and moisture before they descend ;—that descending volumes may come also from the adjacent atmosphere on the north, not containing heat or moisture brought from the tropics ;—and that, as a general fact these cold, dry masses of air, sinking quietly, or poured down with force and violence, to spread over the surface as cold and violent winds, do cause many otherwise inexplicable extremes of cold in the winter and spring particularly.

The descent of masses of heavy, cold air, must often be induced simply to fill the void caused by contraction of the volume of air from which rain and snow fall. All along the belt of westerly winds this contraction is going on, and this very rapidly during all the colder months. Moving with a constant motion toward the earth, as well as along the surface, it is only a natural vicissitude of this condition, that the descending mass should, at intervals, be poured, like a mass of cold water, over the border of the humid belt, producing the extremes that so often appear to *strike down from above*.

I do not remember seeing much reference, hitherto, to descending volumes of air on the northern border of this belt of circulation, yet as the trade winds steadily withdraw the air beneath, toward the tropics, it must necessarily return above ; and it must descend as it returns. If all these movements were perfectly regular, we should see no spasms of severity, but as, in fact, there are many days of steadily expanding heat in spring, the days on which the contraction occurs are only the more violent. Hence those heavy pouring winds, that bring such severity of cold during the spring months ; winds which are neither winds of propulsion, nor of aspiration, but merely the forcing down of cold masses of air from the upper atmosphere, to spread along the surface to some extent, but to be perpetually recruited and renewed from above. An easy experiment will illustrate the condition, by dropping the upper sashes of high windows in a heated room on a cold day,—the downward movement will prove unexpectedly tangible and heavy, and as conspicuously marked, almost, as if water were poured through the windows.

On several occasions during the present month of April, the weather in the seaboard States has exhibited this phenomenon. All of the severely cold weather, for the season, has been *initiated* at the point where its greatest severity was experienced ; not being transferred along the surface from any point at the west, or at the north. For many days of the present month (April) these cold and heavy winds have been felt in the country east of the Alleghanies, when in no single instance that I can trace, has there been any connection or conformity of movement from the western or northern interior. Like severity has often existed there, but the fact, and all its relations, was local in this sense, or was not connected or continuous with other districts.

When the enormous friction of atmospheric contact with the surface is taken into account, it must be apparent that there can be few winds of propulsion. I think it may be fairly assumed that the greater number of winds in cold weather particularly, are *winds that descend*, and that to this descent most of their continued force is due. On Saturday, April 11, and Sunday, April 12, the thermometer fell at Washington under the influence of these obviously descending winds until in the night of the 12th it reached a minimum of  $19^{\circ}$ , while for three days previous no place west of the Alleghanies in the same latitude was below  $50^{\circ}$ , and the average temperature at Fort Sully, on the Missouri, 1200 feet above the sea, and in latitude  $45^{\circ}$  north, was as warm as at Philadelphia, at sea level, in latitude  $42^{\circ}$  N. This remarkable depression of temperature could not have been due to radiation, since all the areas west and north were even more exposed to radiation, being clear and calm ; nor was it due to north or northwest winds propagated along the surface, for there had been no cold winds from these points at the west or north for several days. Nor was there any general storm to effect a displacement or shrinkage, at least no storm on the continent. There may have been some general storm, or shrinkage at sea, however, facilitating or inducing a *descent of heavy masses of cold air from above* to supply the partial vacuum.

I venture to assume, therefore, a large measure of influence in causing extremes of cold in these latitudes to the descending volume of air incident to the shrinking and wasting of heat and moisture from the atmospheric current eastward in the course of traversing the continent. Its northern border is perpetually invaded by fitful alternations of displacement ; sometimes getting calm and intensely cold, to reduce the temperature in winter to  $10^{\circ}$ ,  $20^{\circ}$  or  $30^{\circ}$  below zero ; and in spring, when the general accession of heat gives a more free play of the forces, a frequent recurrence of heavy northwest dry winds *poured from above*, and from the north, displacing and condensing the local, or surface atmosphere ; and this overflow is almost constantly repeated until the whole system of circulation has been swept beyond our limits at the north, by the advance of summer. During most of the summer months the rarifying and expanding forces prevail so completely, as to remove all these phenomena far to the north, or possibly to another hemisphere.

We shall undoubtedly be compelled to revise our views as to the primary or leading condition of general storms. The barometer is by no means a certain guide, and instances of severe storms with continuing high pressure throughout are frequently recurring. The recent severe storm of Saturday and Sunday, April 25th and 26th. This storm began with the barometer .15 above the mean, and scarcely fell below the mean (of 30. inches) after ten or twelve hours of continued severity, and when at its height here, on Saturday evening. At Pittsburgh, Cincinnati, Louisville, &c., there was also no perceptible depression below the mean, the barometer being generally at almost exactly 30 inches. No storm was anticipated by the signal office, nor were there any evidences such as usually appear, justifying anticipations of a severe storm. Yet few storms have been as severe, the N. E. wind of Saturday night being extremely heavy here, while northeastward, to Nova Scotia, the slow but certain progress continued throughout the day and night of Sunday. On Monday morning, it is true, a considerable barometric depression appears in Maine and Nova Scotia, of half an inch, or more, in places, but this appears to have set in eastward of New York, almost exclusively. The storm was violent and long continued at New York and southward, with very little barometric depression, not enough to warrant expectations of a storm, or any severity of winds. There have been several conspicuous instances of a similar character since the Signal Service observations gave us such excellent opportunities for observation.

I repeat, that the evidence is cumulative in support of the position that the atmospheric movement in the colder seasons in these latitudes is one of constant descent of volumes; that the cold gales of the spring months, strike in at areas east of the Alleghanies from the northwest, when they are unknown west of that line; and occur in repeated instances not only when by no possibility they could be continuous, or connected with like movements propagated from the northwest, but also when the winds, even so near as Pittsburgh, blew all the time in an opposite direction.

The almost inexplicable phenomena presented by the severity, the persistence and force of these winds, with the low temperature they bring, become easy of solution, under the view that their volume is perpetually renewed at all points where they prevail, by constant *pouring from above*, as if a current of cold water was renewed and enforced in its movement by so pouring a stream *downward*, as well as along the surface. On each of the last three days the facts of such forcible descending winds were experienced here, and during the full period of ten days preceding there was, as the Signal Office charts will show, a marked absence of west or northwest winds at all points of the western or northwestern interior, from which it is usually supposed these high cold winds are derived, and propagated eastward along the surface to the Atlantic Coast. In fact, for a week from April 25th to May 1st, the weather was warmer at Pembina, lat. 49° N., than at Philadelphia, in 42° N., being 44° for the 1 A. M. observation at Pembina, to 42° for the same at Philadelphia.